DOCUMENT RESUME

ED 155 697 CS 204 136

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TITLE Protocol Analysis of Writing Processes.
PUB DATE Mar 78
NOTE 27p.; Paper presented at the Annual Meeting of the American Educational Research Association (Toronto, Canada, March 1978)

EDRS PRICE MF-$0.83 HC-$2.06 Plus Postage.
DESCRIPTORS *Cognitive Processes; *Componential Analysis; *Composition (Literary); Creative Writing; Higher Education; Language Arts; *Models; Thought Processes; *Writing; Writing Skills; *Written Language

ABSTRACT

This paper presents a tentative model of the writing process that has been developed according to the technique of protocol analysis. (A protocol is a description of the activities, ordered in time, in which a subject engages while performing a task.) The model identifies subprocesses of the composing process and their organization; minor variations of its simple control structure allow it to describe individual differences in composing styles. On the basis of this model it is proposed that composition consists of three major processes: planning (retrieval, inferencing, and organizational subprocesses), translating (generating text corresponding to the internal representation under the plan's guidance), and editing (examining the text for grammatical and semantic errors and for failure to match the plan). Diagrams and references are included. (DF)

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# Protocol Analysis of Writing Processes

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Paper to be presented March 31, 1978, at the Annual Meeting of AERA, Toronto, Ontario, Canada, as part of the Symposium chaired by Dr. Lynn L. Morris, "A Major Issue in Assessment of Writing Proficiency: What is Good Writing?"

CS204 136

# Protocol Analysis of Writing Processes

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Many have recognized that attention to process is potentially very important for the teaching of writing (Britton et al., 1975; Young et al., 1970). Unfortunately, relatively few researchers have studied writing processes. While noteworthy exceptions may be found in the work of Emig (1971), Zollner (1969), and Harding (1963), it is still true, as Britton et al. (1975) say, that "...there has been very little systematic direct observation of fluent writers at work."

Cognitive psychologists have developed the technique of protocol analysis as a powerful tool for the identification of psychological processes (Newell & Simon, 1972). Protocol analysis has most typically been used to identify processes in problem solving tasks. However, we will see that it can be used to identify processes in writing as well.

In this paper, we will

1. describe the technique of protocol analysis;
2. show how it can be used to identify writing processes; and
3. describe some early results in identifying writing processes which Dr. Flower and I have obtained through the use of protocol analyses.

What is a Protocol?

A protocol is a description of the activities, ordered in time, which a subject engages in while performing a task.

A protocol, then, is a description, but not every description of a task performance is a protocol. Often we describe tasks mentioning only their outcomes or goals. We may say, for example, "My Great Dane, Spot, convinced me to give him his supper." This description tells us that the dog did one or more things to get food, but it doesn't say what these things were or in what order they occurred. The description, therefore, is not a protocol. The description below is a protocol, however.

Experimenter: [seated at dinner table cutting into his steak]

Spot: [seated directly behind the experimenter, his chin resting on the experimenter's shoulder. Spot watches intently as the steak is being cut.]

Exp: [slices a large piece of steak with his fork]

Spot: [tail wags, stomach rumbles ominously]

Exp: [begins to raise fork to mouth]

Spot: [places paw on experimenter's arm and looks intently into experimenter's eyes]

Exp: [says, "Spot!"]

Spot: [removes paw, continues to watch intently]

Spot: [drools into experimenter's shirt pocket]

Exp: [abandons own dinner and feeds dog]

This is a protocol because it listed the activities which Spot engaged in and the order in which they occurred. In the same way, when we collect protocols of people solving problems, we are interested not just in the answers they

give us, but, also and more importantly, in the sequence of things they do to get those answers. For example, they may draw diagrams, make computations, ask questions, etc., and they do those things in a particular order.

Verbal Protocols

In a verbal, or "thinking aloud" protocol, subjects are asked to say aloud everything they think while performing the task. They are asked to say everything that occurs to them, no matter how trivial it may seem. Even with such explicit instructions, however, subjects may forget and fall silent--completely absorbed in the task. At such times the experimenter will say, "Remember, tell me everything you are thinking. Figure 1 shows a typical thinking aloud protocol for a subject solving a water jug problem.

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Insert Figure 1 about here

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Water jug problems require the subject to measure out a specified quantity of water using three jugs, as shown in Figure 2. None of the jugs has calibration marks. That is, there are no marks indicating a one quart level, a two quart level, etc., The subject is told only how much each jug will hold when it is full.

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Insert Figure 2 about here

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One typical water jug problem requires the subject to measure out 31 quarts when jug A will hold 20 quarts; jug B, 59 quarts; and jug C, 4 quarts. The problem can be solved in four steps as follows:

WATER JUG PROBLEM: GIVEN JUG A WHICH CONTAINS 9 QUARTS;
JUG B, 42 QUARTS; AND JUG C, WHICH CONTAINS 6 QUARTS,
MEASURE OUT EXACTLY 21 QUARTS.

1. UH, THE FIRST THING THAT'S APPARENT IS HALF OF B IS, IS THE UH, THE
2. AMOUNT THAT YOU WANT.
3. EXP: UH HUH.
4. UM, YOU CAN'T GET 21 FROM JUST MULTIPLYING UP A OR C,
5. YOU GET 18 AND 18 RESPECTIVELY, THAT'S AS CLOSE AS YOU CAN GET,
6. I GUESS. UM, SO I'LL TRY TO THINK OF THE DIFFERENT COMBINATIONS THAT
7. MIGHT,..COME UP WITH A SURPLUS..OR DEFICIT OF THE 21 QUARTS,.. AND
8. 9 AND 6 ARE, 15...IF YOU TOOK TWO 9'S AND TWO 6'S, YOU'D HAVE 30 WHICH
9. WOULD LEAVE YOU...AND POUR THEM INTO THE 42 CONTAINER, YOU'D HAVE A,
10. AN OPEN SPACE OF A, 12, WHICH MEANS NOTHING. HOW ABOUT...SEE...NOW I'M
11. TRYING TO THINK OF HOW CLOSE TO 42 YOU CAN GET WITH A 9 AND THE 6 QUANTITIES.
12. YOU CAN GET...I FORGET THE 7 TABLE. IT'S BEEN A LONG TIME SINCE I'VE
13. HAD TO MULTIPLY OR ANYTHING SO YOU'LL HAVE TO GIVE ME SOME TIME. UM,
14. 9 TIMES 5 IS 45.. HM, 6 TIMES 7 IS 42, I THINK. IS THAT RIGHT?
15. EXP: UH HUH.
16. OK, SO YOU CAN, UH,..FILL B WITH C, EVENLY,LL
17. EXP: YOU COULD..
18. SO..IF YOU WERE TO TAKE..36..HM, OH, UH, 6 TIMES 4 IS 24..AND IF YOU, UH,
19. WHAT I'M TRYING TO GET RID OF IS, IS, 3 QUARTS THERE...
20. EXP: GOOD.
21. SO IF YOU WERE TO, UM,...STILL 24. I, I WAS TRYING TO THINK POSSIBLE,
22. SOME WAY, OF ..THE DIFFERENCE BETWEEN THE 6 AND THE 9 IS 3 QUARTS. I
23. WAS TRYING TO THINK OF..A WAY TO UH...OH, HOW ABOUT..YOU PUT THE 3, 6
24. QUART QUANTITY INTO THE 42 BOTTLE, WHICH IS 18, THEN THE RUN OFF, FROM
25. POURING A 9 INTO A 6 WHICH IS 3 AND 18 IS 21.
26. EXP. GOOD.

Figure 1. Protocol of a water jug problem.

| Jug A | Jug B | Jug C |
|---|---|---|
| MEDIUM | LARGE | SMALL |
| X quarts | Y quarts | Z quarts |

Figure 2. Non-calibrated jugs used to solve the water jug problem.

1. Fill jug B.
2. Fill jug A from jug B, leaving 39 quarts in B.
3. Fill jug C from B, leaving 35 quarts in B.
4. Empty C and fill it again from B, leaving the desired quantity, 31 quarts, in B.

It is helpful when you analyze a protocol to have done the task yourself beforehand. So, before beginning to analyze the protocol in Figure 1, try to solve the following problem.

**Measure 100 quarts given jug A, holding 21 quarts; jug B, holding 127 quarts; and jug C, 3 quarts.**

When you finish this problem, solve the problem in Figure 1 if you have not already done so.

An Example of Protocol Analysis

Now, let's examine the protocol in Figure 1 in detail and try to make some reasonable guesses about what the subject was doing.

In his first sentence, the subject mentions something which appears to be irrelevant to solving the problem. He mentions the fact that the desired amount (21 quarts) is just half the quantity contained in jug B. Now, division is a very useful operation in many algebra problems. In this problem, if we could divide jug B in half, the problem would be solved. But alas! There is no division operation in water jug problems. All we can do is add and subtract the quantities in jugs A, B, and C. Why, then, does the subject notice that the desired quantity is half of B? The simplest answer seems to be that he is confusing water jug problems (perhaps because he isn't thoroughly familiar with

them) with the more general class of algebra problems. If this answer is correct, we would expect that the subject would stop noticing division relations as he gains more experience with water jug problems. In fact, that is what happened.

On line 3, the experimenter (EXP) does just what the experimenter is supposed to do--that is, he is non-commital. In general, the experimenter should answer only essential questions and remind the subject to keep talking.

From lines 4 and 5, we can guess that the subject has successively added 9's to get 9, 18, 27...and 6's to get 6, 12, 18, 24...and realized that neither sequence includes 21. From lines 6 through 10, we can see that the subject begins to consider combinations of 9's and 6's which may be added together to obtain interesting sums, or subtracted from the 42 quart container to obtain interesting differences. While considering sums, the subject fails to notice that the sum 6 + 6 + 9 solves the problem.

In lines 11 through 14, the subject tries to find out if 42 quarts can be obtained by adding 9's and 6's. The answer is "yes," but it doesn't help the subject to find a solution. It appears to be a "blind alley." In this section, the subject indicates several times that he doesn't feel confident about multiplication.

In lines 15 and 17, the experimenter provides the subject with a small amount of information by confirming his uneasy suspicion that six times seven equals forty-two. On occasion, the experimenter must decide whether or not to provide information the subject requests. In this case, since the experimenter was really interested in water jug

problems rather than in arithmetic, he decided to supply an arithmetic fact.

In lines 18 and 19, the subject realizes that if he had a way to subtract 3 quarts from 24 quarts, he could solve the problem. In line 20 the experimenter appears to slip by providing the subject with approval, when he would better have remained silent. In line 21, the subject is still thinking of working from 24 quarts. In line 22, he discovers a way to add (rather than subtract) 3 quarts by pouring A into C and catching the overflow. In lines 23 and 24, he decides to work from 18 quarts rather than 24 quarts and then (on line 25) immediately solves the problem.

Now, let's stand back from the details of the protocol to see if we can characterize the whole problem solving process that the subject engaged in. Before reading further, review the discussion of the protocol and then try to characterize the problem solving process yourself.

One way to characterize the problem solving process is to describe it as a search for an operator or a combination of operators to solve the problem. (In this case, the operators are arithmetic procedures such as division and subtraction.) In Figure 3, where we have diagrammed this search process, we can see that search proceeds, generally, from simple to complex--that is, from single operators to complex combinations of operators.

Up until line 18, the subject's search for a solution could have been guided by the problem statement above. That is, by reading the problem statement, the subject could have decided that what was needed to solve the problem was some combination of algebraic operators. Up to line 18, he could simply be trying one combination after another. We call this sort of search "forward search," that is, it is search suggested by the problem statement

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Insert Figure 3 about here 10

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| | lines in protocol | operator applied | outcome | comment |
|---|---|---|---|---|
| forward search | 1-2 | divide by 2 | fail | operator not available |
| | 4-5 | add 9's | fail | |
| | 4-5 | add 6's | fail | the subject apparently doesn't try all combinations because he fails to notice that 6 + 6 + 9 = 21 |
| | 6-8 | add 9's and 6's | fail | |
| | 7-10 | add 9's and 6's and subtract from 42 | fail | |
| means-ends analysis | 18-19 | notice difficulty | succeed | the subject notices the operators above got him no closer to 21 than 24; he sets the goal of finding an operator to subtract 3 |
| | 22 | overflow 9 into 6 | fail | |
| | 23-25 | add 6 three times and overflow 9 into 6 | succeed | |

Figure 3. Analysis of water jug protocol.

alone. In lines 18 and 19, however, the subject formulates a goal on the basis of his difficulties in solving the problem. He notes that he hasn't been able to get closer than three quarts to the answer and attempts to find an operator that will subtract three quarts. This goal depends not just on the problem statement but also on the subject's experience in trying to solve the problem---that is, on his distance from the goal. It is a form of means-ends analysis in which the subject attempts to find a means to the end of reducing his distance from the goal.

The whole solution process then consists of

1. An initial phase of forward search through an increasingly complex sequence of operators, followed by
2. A phase of means-ends analysis in which the subject succeeds in finding a solution.

In analyzing a protocol, we attempt to describe the psychological processes which a subject uses to perform a task. To do this, it is useful to be familiar both with the properties of the task and with the problem solver's component psychological processes. In analyzing the water jug protocol above, knowing that the task required algebraic operators and that human problem solvers often use processes of forward search and means-ends analysis helped us to recognize how the subject had organized these processes in his search for a solution. In the same way, when we analyze other protocols, knowledge of other tasks and of other psychological properties will be useful. This is not to say that we must already understand a performance before we can analyze it. It is just that when we do understand somethings about the performance, we can use them very profitably to learn other things.

In analyzing the water jug protocol below, knowledge of the psychological phenomenon of set is very helpful. The problem used in this protocol can be solved in either of two ways. It can be solved by the procedure B - A - 2C, or it can be solved by the simpler procedure: A - C. Just before solving this problem, the subject worked a series of six problems, all of which required the procedure B - A - 2C for solution. As a result, we would expect the subject to show a set to use the "B - A - 2C" procedure. As lines 6 through 9 show, the subject actually solves the problem by the "A - C" procedure. However, if we look back to lines 3 and 4, we see that the subject's first problem solving attempt was to subtract A from B. This suggests that he started to use the B - A - 2C procedure even though he didn't carry it through. Clearly, analyzing the protocol gives us evidence about the subject's solution process that we can't get just by looking at the answer.

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Insert Figure 4 about here

---

The protocol of the "age problem," shown below, illustrates again the usefulness of knowledge of task demands and component psychological processes for understanding human performance. As in many problems, part of the difficulty of "age" problems lies in keeping track of relevant information. Unless problem solvers are very careful in labeling information, they are likely to confuse a person's age at one time with the same person's age at a different time. For example, problem solvers who have only a single label which they use both for "Mary's age now" and "Mary's age then," let us say "Mary" or "M", are very likely to confuse Mary's age now with Mary's age then. This is just what happens in this "age" problem protocol.

1 UH, ** I'M ADDING AND SUBTRACTING HERE.
2 EXP: SAY WHAT YOU'RE ADDING AND SUBTRACTING.
3 O.K., WELL, 23 FROM $( * IS * * UH * * REMINDS ME WHEN
4 WE KEEP SCORE WHEN WE PLAY CARDS. 26 * * OH, O.K., ER IT
5 WOULD BE EASY ENOUGH. YOU TAKE * * UM * * O.K. HOW DO WE
6 GET THIS INTO WATER AND JUGS NOW. * BECAUSE YOU COULD TAKE A *
7 WHICH IS 23, AND POUR IT INTO C WHICH IS 3, THERE WE GO,
8 POUR IT INTO C WHICH IS 3, AND 20 WOULD BE WHAT WOULD GO, *
9 RIGHT INTO B.
10 EXP: GOOD..

Figure 4. A water jug problem protocol.

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Insert Figure 5 about here

---

Analysis of the Problem

To solve this problem, it is necessary to distinguish four quantities--John's age now, JN; John's age then, JT; Mary's age now, MN; and Mary's age then, MT. Three equations can be derived from the problem statement.

JN = 2 JT  i.e., John is twice as old now as he was then

MT = JN + 3  i.e., Mary then was three years older than John is now

JN = 1/2 MN  i.e., John now is half as old as Mary now

In addition, because we know that John and Mary age at the same rate, we can derive a fourth equation:

JN - JT = MN = MT  i.e., the difference between John's age now and John's age then is the same as the difference between Mary's age now and Mary's age then.

Armed with these equations, those adept at algebra can determine that John's age now is 6 and Mary's age now is 12.

Now, let's see what our subject has done. From lines 15 through 29, she frequently confuses John's and Mary's ages now with John's and Mary's ages then. In fact, nowhere in the protocol is there any evidence that she ever makes the now-then distinction. In lines 27 and 28, she derives two equations:

Mary = John + 3, and

Mary = 2 · John

The second one is correct, but the first is not because it confuses Mary's age then with Mary's age now. The subject then solves these equations and concludes, incorrectly, that John's age now is 3.

EXP: HERE IS ANOTHER PROBLEM.
JOHN IS NOW TWICE AS OLD AS HE WAS WHEN MARY WAS THREE YEARS OLDER THAN HE IS NOW, BUT HE IS ONLY HALF AS OLD AS MARY IS AT PRESENT.
NOW HOW OLD ARE THEY?

1 UM, UM, JOHN IS NOW TWICE AS OLD AS HE WAS WHEN MARY WAS
2 THREE YEARS OLDER THAN HE IS NOW. BUT HE IS ONLY HALF AS OLD AS MARY
3 AT PRESENT. UM, UM, THREE YEARS OLDER IS THE ONLY NUMBER SUPPLIED,
4 SO I'M GOING TO START WORKING FROM THERE. I GUESS, AND UH,...
5 EXP: WHAT ARE YOU THINKING?
6 I GET ABSOLUTELY NOTHING FROM THOSE QUESTIONS.
7 I AM DRAWING A BLANK AT THE MOMENT, UM, I AM TRYING TO SORT OUT JOHN
8 AND MARY, I GUESS, HERE, BECAUSE, THE WORDS DON'T LEND THEMSELVES TO
9 BE DECIPHERED INTO, LIKE, TWO NEAT LITTLE JOHN AND MARY COLUMNS, UM,
10 AND IT'S HARD. OK. JOHN IS TWICE AS OLD..NOW..THAN WHEN HE WAS WHEN
11 MARY WAS THREE YEARS OLDER THAN HIM.. OH WOW! UM, BUT HE IS ONLY HALF
12 AS OLD AS MARY AT PRESENT...SO, UM, JOHN EQUALS, HM, NOW I'M TRYING
13 TO THINK OF A .. I DON'T KNOW WHY IT JUST OCCURRED TO ME THAT MAYBE IF
14 I PLUGGED JOHN AND MARY AND THE INFORMATION INTO LITTLE, LITTLE, YOU
15 KNOW, JOHN EQUALS MARY PLUS THREE, OR SOMETHING LIKE THAT, YOU KNOW,
16 LITTLE X, Y?
17 EXP: UH HUH.
18 I DON'T KNOW WHAT YOU CALL THEM.
19 EXP: EQUATIONS.
20 EQUATIONS. OK. GOT TO WARN YOU, I FLUNKED MATH IN SIXTH GRADE. SO UM,
21 UM, AH...JOHN IS NOW TWICE AS OLD AS HE WAS WHEN MARY WAS THREE YEARS
22 OLDER THAN HE IS NOW.,, OK, SO JOHN EQUALS..UM, MARY AND THREE..., WHICH
23 DOESN'T DO ME ANY GOOD, AND HE IS ONLY HALF AS OLD AS MARY AT PRESENT,
24 SO I HAVE TO KNOW HOW MUCH JOHN IS WORTH FIRST, HERE, AND, UH,..MARY IS
25 THREE YEARS OLDER THAN HE IS.., AND HALF AS OLD AS MARY AT PRESENT. UM,
26 MARY IS THREE YEARS OLDER THAN HE IS NOW, BUT HE IS ONLY HALF AS OLD AS
27 MARY AT PRESENT... SO HE HAS TO BE HM...MARY IS THREE YEARS OLDER THAN
28 HE IS NOW...AND MARY IS TWICE HIS AGE. THEN HE'S GOT TO BE THREE YEARS
29 OLD.
30 EXP: ALL RIGHT.

Figure 5. Protocol of an age problem.

Protocol Analysis Applied to Writing

Figure 6 shows the first 27 lines of a writing protocol (about 10% of the full protocol). The writer was a volunteer who knew that she was to engage in writing study for about an hour. She knew that she would be asked to "think aloud" as she produced a short essay. She did not know the essay, however, until she arrived for the tape recording session.

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Insert Figure 6 about here

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Analysis of the protocol

In analyzing this protocol fragment, we will call attention to just one class of processes which we consider especially significant; understanding processes. What we refer to here as understanding processes are, we believe, what Stoehr (1967) calls thinking and Van Nostrand (1976) describes as a learning process. Evidence that understanding processes are at work may be seen in changes in the writers understanding of the topic as writing proceeds. In lines 1 through 3, the writer identifies motivation with grades. In lines 6 and 7, she introduces the idea of personal satisfaction but is not at all sure that this is a source of satisfaction distinct from grades. In lines 8 through 12, personal satisfaction is given a very important role, but it is not clear how the writer relates it to grades. In lines 13 through 15, two sources of personal satisfaction are identified: grades and the production of high quality work. A relation between the two sources of satisfaction is specified in lines 15 and 16 and again in lines 21 through 23. The relation is that if the work is of good quality, a grade is not necessary for satisfaction. In lines 24 and [illegible] contradictory relation is noted, that is, that grades are the initial motivator for all essay

W: Ok, um, the issue is motivation and the problem of writing papers. For me, motivation here at Carnegie-Mellon is the academic pressure and grades that are involved, so I'd better put that down. ..and grades... Um, they kind of compel me, that's really what motivation is, um, kind of to impel or start or a, momentum. (Pause.) Ok, I suppose from the academic pressure of the grades, I'm not sure whether, I think personal satisfaction is important, but I'm not sure whether that stems from academic pressures and grades, or whether-- I would say personal satisfaction is a major issue. Ok, um. Oh.

L: What are you thinking?

W: I'm trying to think of the first sentence to start with. Um, maybe something like, personal satisfaction is the major motivating force in the writing of my papers and reports. Ok, I'm trying to think of; ok, I want to somehow get it into the academic pressures now. Um, well maybe not so soon. Ok. Not only do I get satisfaction from my grades, but I also get satisfaction in turning in something that is good quality. So, if I'm happy when I write a good paper, it really doesn't matter what kind of grade I get back on it, if I'm happy with it. So, um, um, let's see. Um, what are the-- I'm thinking of, I'm trying to relate personal satisfaction between academic pressure and the grades, but I'm not really sure how to do it, how to branch it. I'm really having a hard time getting started. Well, maybe I'll just write a bunch of ideas down, and maybe try to connect them after I finish. Ok. When I feel that I've written a high quality, and I put in parentheses, professional, paper, um. to be graded, when I submit it, the grade is not always necessary for the teacher to have the same. Ok, that's kind of _____ _____; I'll check with that one. Ok, and-- Let's see what else. Um, but (a)course, the reason I'm writing the paper in the first place is for that grade, (of) or to relate that back. Those two ideas are very interlocked,-maybe that's not the right term.

Figure 6. A writing protocol.

writing. In lines 26 and 27, these relations are described as "interlocked" rather than as contradictory. The contradiction between the relations is recognized later in the protocol. In large measure, the final essay (shown in Figure 7) is concerned with the resolution of this conflict.

Our major point is that in the course of writing the essay, the subject's understanding of the topic changed radically. At first, she believed her motivation had a single source. By the end of the essay she recognized that it had two sources which were related in a complex way. Writing in this case clearly involved understanding processes.

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Insert Figure 7 about here

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Protocol Analysis--More Generally Considered

As we have seen, protocol analysis can be used as an aid in understanding a wide variety of tasks from simple problem solving in apes to complex performances such as chess playing and writing in humans. Typically though, protocols are incomplete. Many processes occur during the performance of a task which the subject can't or doesn't report. The psychologist's task in analyzing a protocol is to take the incomplete record which the protocol provides together with his knowledge of human capabilities, and to infer from these a model of the underlying psychological processes by which the subject performs the task.

Analyzing a protocol is like following the tracks of a porpoise. Occasionally, the porpoise reveals itself by breaking the surface of the sea. Its brief surfacings are like the glimpses which the protocol affords us of underlying mental process. Between surfacings, the mental process, like the

F1 Personal satisfaction is the major motivating force in the writing of my
F2 papers and reports. The emphasis on 4.0's here at CMU causes grades to
F3 become an instinctive motivator for myself. Acquiring good grades does, in fact, give me personal satisfaction.

F4 The initial motivator in the outset of writing a paper is the fact that a
F5 grade will be attached to it upon completion. I feel that my role as a student requires all of my efforts to be put forth into course work, which includes the writing of papers.

F6 After I begin writing a paper, the grade emphasis diminishes and a higher
F7 level of personal satisfaction takes over. When I feel that I've written a high-quality or professional paper to be submitted for grading, it is
F8 not mandatory for the teacher to have the same opinion. But of course, this somewhat contradicts my earlier statement that the motivation for writing a paper is to achieve the ultimate goal--a good grade.

F9 Thus, the combination of the grade "initiator" and later a higher level of personal satisfaction is what motivates me to write my college papers and reports.

Figure 7. The completed essay.

porpoise, runs deep and silent. Our task is to infer the course of the process from these brief traces.

The power of protocol analysis lies in the richness of its data. Even though protocols are typically incomplete, they provide us with much more information about processes by which tasks are performed than does simply examining the outcome of the process. Knowing what answer people get in solving problems is much less informative than catching glimpses of the complex processes by which they arrive at the answer.

## A Model of the Writing Process Derived through Protocol Analysis

While space does not permit me to describe our research in detail, Dr. Flower and I carried out protocol analysis of a number of writing protocols over the last two years. The results of this research have led us to propose the tentative model of the writing process outlined below.

## The Model

The unique features of the model are:

1. It identifies not only subprocesses of the composing process but also the organization of those subprocesses.
2. Minor variations in its simple control structure (the monitor in Figure 9) allow it to describe individual differences in composing styles.

While the model is provisional, it provides a first approximate description of normal composition which can guide research and afford a valuable starting point in the search for more refined models.

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Insert Figures 8 and 9 about here

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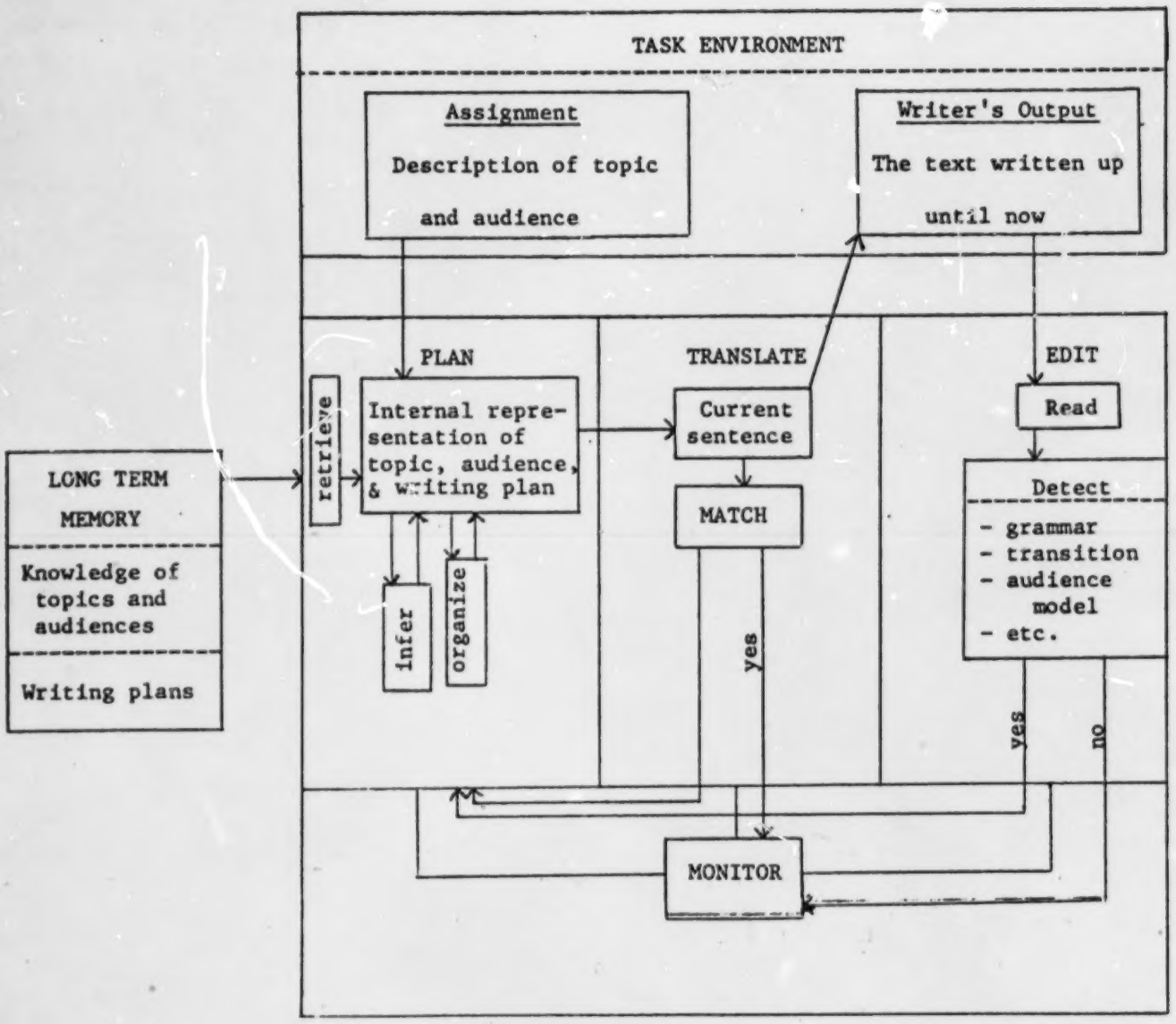


Figure 8. The structure of the composition process and its relation to the writers' long term memory and to the task environment.

Configuration 1 (depth first)

1. (No new element, planning not complete)
   ——>plan
2. (New element) ——>translate
3. (New text) ——>edit

Configuration 2 (get it down as you think of it, then edit)

1. (No new element, planning not complete)
   ——>plan
2. (New element) ——>translate
3. (Translation complete) ——>edit

Configuration 3 (perfect first draft)

1. (No new element, planning not complete)
   ——>plan
2. (Planning complete) ——>translate
3. (New text) ——>edit

Configuration 4 (breadth first)

1. (No new element, planning not complete)
   ——>plan
2. (Planning complete) ——>translate
3. (Translation complete) ——>edit

Figure 9. The Monitor.

Figure 8 shows the structure of the composition process and its relation to the writers' long term memory and to the task environment. The task environment includes the writing assignment, that is, a description of the assigned topic and the intended audience. Once writing has begun, the task environment also includes the text which the writer has produced so far. This text is a very important part of the task environment because the writer refers to it repeatedly during the process of composition.

We assume that writers have knowledge relevant to many topics and many possible audiences stored in long term memory. They may also have generalized writing plans, perhaps in the form of a story grammar (Rumelhart, 1975), or in the form of a list of questions such as the journalists' "Who, what, where, when, and why?"

We propose that composition consists of three major processes: planning, translating, and editing. The planning process consists of retrieval, inferencing, and organizing subprocesses. Its function is to take information from the task environment and from long term memory and to generate internal (mental) representations of topic knowledge, the audience, and writing plans. Writing plans may be drawn from long term memory or may be generated by the organizing subprocess.

The function of the translating process is to generate text corresponding to the internal representation under the guidance of the writing plan. This process contains a "MATCH" subprocess which checks the text to be sure it actually matches the internal representation. If it does not, a subprocess is activated to improve the match.

The editing process examines the available text to detect grammatical or semantic errors, failure to match the writing plan, and mismatches between the audience model and text. It consists of a number of subprocesses, each designed to detect and fix a particular type of error in the text. Some subprocesses operate at the sentence level to correct grammatical or semantic errors. Others, which operate more globally, may be concerned with matters such as consistency of style and completeness of context. An editing subprocess designed to supply missing context may recursively employ the whole composition process, and thus the writer may actually write a small essay to fill a gap in his larger essay.

The sequencing of subprocesses within the composition process is handled in one way when difficulties are discovered and in another way when processing is trouble-free. When difficulties arise in the translating and editing process, special procedures are called on to deal with the trouble. These trouble-shooting procedures may call parts of other subprocesses into action to help to solve the problem. For example, if an explanation is judged too difficult for the intended audience, the retrieval part of the planning process may be recruited to find a simpler analogy. This new material will then be translated into language and edited as was the material being replaced.

When processing is trouble-free, the processing sequence is determined by the monitor. Figure 9 shows four possible configurations (in production system form) for the monitor. Each configuration yields a characteristic method for constructing essays. The first configuration yields a depth-first composing process. The work of planning, translating, and editing

each sentence is completed before the writer proceeds to the next sentence. With configuration 2, thoughts are written down as they occur to the writer and he edits later. With configuration 3, the writer tries to generate a perfect first draft. Configuration 4 yields a breadth-first composing process. A draft is planned and then written out in full before any editing takes place. Evidence supporting these configurations is provided by Lowenthal and Wason (1977), who describe writing styles among academics corresponding to configurations 3 and 4.

## References


Britton, J., Burgess, T., Martin, N., McLeod, A., & Rosen, H. The development of writing abilities (11-18). London: Macmillan, 1975.

Emig, J. The composing processes of twelfth graders (NCTE Research Report No. 13). Champaign, Ill., 1971.

Harding, D.W. Experience into words. London: Chath and Windus, 1963.

Lowenthal, D., & Wason, P. Academics and their writing. Times Literary Supplement, London, June 24, 1977.

Newell, A., & Simon, H.A. Human problem solving. Englewood Cliffs, N.J.: Prentice-Hall, 1972.

Rumelhart, D. Notes on a schema for stories. In D. Bobrow and A. Collins (Eds.), Representation and understanding. New York: Academic Press, 1975.

Stoehr, T. Writing as thinking. College English, 1967, 28(3), 411-421.

Van Nostrand, A. D. Writing and the dialogue of disciplines. PSI Proceedings, 1976.

Young, R. E., Becker, A. L., & Pike, K. E. Rhetoric: Discovery and change. New York: Harcourt, Brace, and World, 1970.

Zoellner, R. Talk-write: A behavioral pedagogy for composition. College English, 1969, 30(1), 267-320.